# GEOLOGICAL AND HYDROGEOLOGICAL CHARACTERIZATION OF BAGRU PAT BAUXITE MINE AND THEIR IMPACT ON SURROUNDING AQUIFER OF BAGRU PAT AREA, LOHARDAGA

**SYNOPSIS**

**Submitted**

**For the degree of**

**DOCTOR OF PHILOSOPHY (Ph.D.)**

**By**

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**SUPERVISOR**

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**RANCHI UNIVERSITY, RANCHI**
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## 1. INTRODUCTION:

The Bauxite Mine Bagru Pat, located in Lohardaga, is a significant source of bauxite ore in India. Bauxite is the primary source of aluminum, and the mining of this mineral plays a crucial role in the country's industrial and economic development. The Bauxite Mine Bagru Pat has been a key player in meeting the growing demand for bauxite, both domestically and internationally.

The plateau comprises in three distinct units Bagru, Bhusar and Hisri sections are parts of Kisko block of Lohardaga district where mining operations are in progress. The study area is located at about 15 km NW of Lohardaga district headquarters and about 85 km west of Ranchi. The bauxite mining sites are connected by a metalled road up to Bagru village and with black topped road from Bagru to and Lohardaga and to Ranchi. It lies between Latitudes 23" 28' 15" N and 23° 29' 30" N and Longitudes 84°3516" E and 84°3630" E falling in the Survey of India Toposheet No. 73A/11. The lease hold area of HINDALCO measures 214.57 ha. area on the plateau top with elevations ranging from 1038m and 1057m above m. s. 1. The area is characterised by flat topped plateau to undulating plain with moderate slopes.

Lohardaga district consisting of 5 blocks i.e. Kuru, Bhandra, Kisko (study area), Senha and Lohardaga is mainly famous for its bauxite exploration which are found in Bagru group of mines, Pakharpat, Garhpat, Dhudhapat and several other mines.

A number of first order streams emanate on either side of the plateau carrying maximum runoff during monsoon season only for a short duration.

Besides the previous studies, based on the geological mapping of the area by the Geological Survey of India and detailed exploration of the Plateau area by INDAL during the last more than six decades in connection with its mining activities, recently an electrical resistivity surveys were carried out at Bagru mines for groundwater by Geo Exploration Services (Sharma, 1994). A total of thirteen shallow Vertical Electrical Soundings (VES) in the area probing six sites at Hisri, two sites at Daldalia nala and five sites at Bhusar have been undertaken. Only one site suitable for drilling up to 120 - 130m depth b. g. 1. at Hisri with expected yield of 2000 - 3000 1. p. h. has been identified. In Bhusar area five VES were carried out including the site at HINDALCO quarters (previously INDAL) and all the points were found suitable up to about 100 m depth b. g. I. with expected yield of more than 2000 1. p. h. The study reveals the present groundwater conditions, scope of exploration and management through hydrogeological and hydrological evaluation.

## 2. STATE OF THE ART:

Bauxite is one such mineral of great economic importance. Almost all of the aluminum that has been ever produced has been extracted from bauxite. The area under investigation is sustained by Chotanagpur Granite Gneiss associated with intrusions of quartize, older rocks and Deccan Traps. Under suitable chemical condition and leaching through geological time period, the rocks have been transformed into laterite and bauxite remnants.The thickness of the weathered profile varies from 4.0 to 12m thick b. g. 1. Depth of water table varies from 34.45 to 55.93m b. g. 1. In parts of Bagru-Bhusar plateau of Lohardaga is mainly drained by the South Koel and Sankh River and its tributaries. From the groundwater exploration point of view the area is divided into a two distinct hydrogeological units massive crystalline rocks unsuitable for groundwater development and thick zone of weathered rocks with rich laterites is suitable for ground water development highly required for domestic as well as irrigation purposes. Reclamation plans in Bagru Pat include many of the following concerns: There is good scope for Ground Water development through deep bore well in this region, drainage control, several measures for ground water recharging through the rainwater harvesting ponds ,preservation of top soil, segregation of waste material, controlling measures for soil erosion through plantation, solid waste disposal, control of fugitive dust, and restoration of waste and mine areas. Thus, mining is an important activity which provides employment to many and even adds to the economy of the country.

## 3. GENERAL GEOLOGY & TOPOGRAPHY:

India is endowed with large reserves of bauxite. It is the 5th largest producer in the world. Bauxite is produced by chemical weathering typically under tropical and sub-tropical conditions.

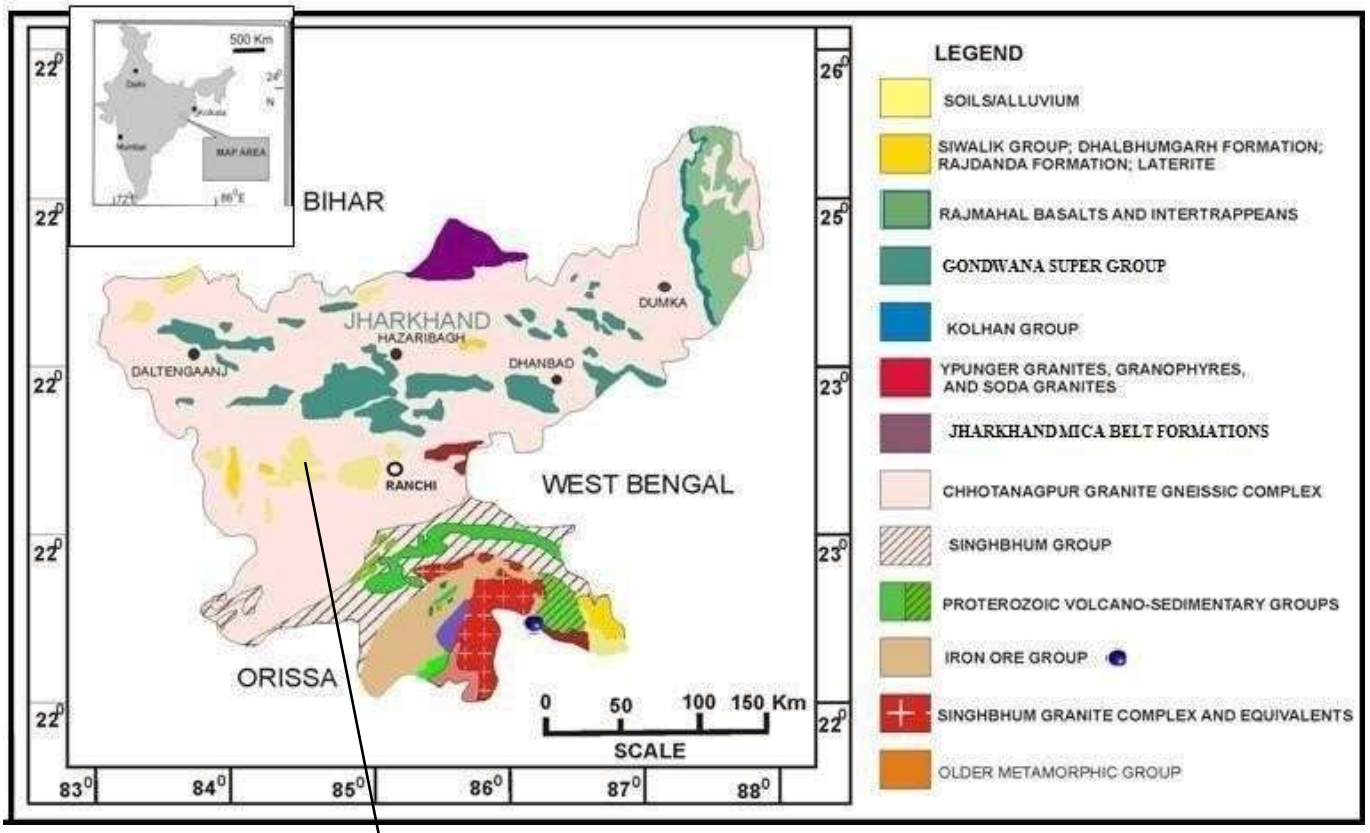
- Bauxite deposits are confined to 30˚N & 30˚S of the equator.
- Gibbsite : Al203. 3H20; Boehmite: Al203.H20 and Diaspore: Al203.H20 are the constituent minerals of bauxite
- Bauxite is the raw material most widely used in the production of aluminum on a commercial scale.

The usual color of bauxite is pink but if of low iron content it may tend to become whitish in color and with increase in iron it is reddish brown in color. Very commonly bauxite deposits are associated with the rock type known as laterite which forms a kind of ferruginous crust over any type of rock whether igneous, sedimentary, or metamorphic.

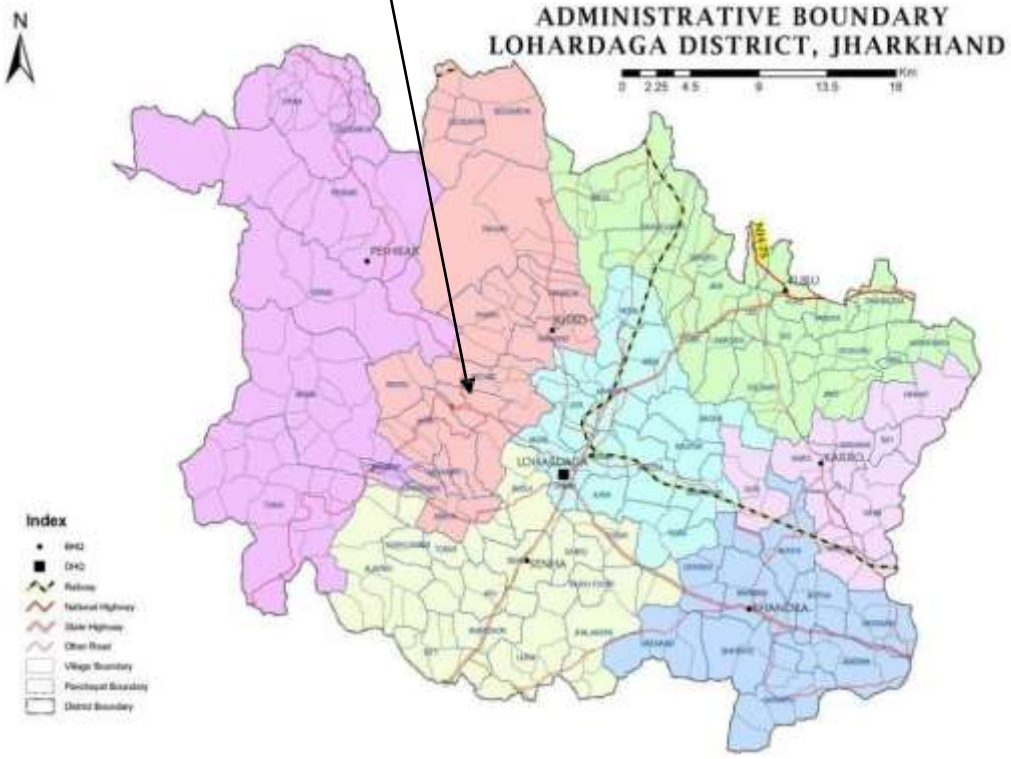
The study area is underlain by Chhotanagpur granite gneissic complex (CGGC) of Archean age which occurs as large batholitic masses and forms the basement rock. On weathering of these rocks laterites, bauxite and kaolinites are formed during recent and sub-recent age. The Chhotanagpur granite gneisses are represented by biotite hornblende gneiss and biotite hornblende granite and are intruded by aplite, pegmatite and quartz veins which are emplaced in fracture within the parent rocks.

The granites and gneisses show moderate to well pronounce vertical to sub vertical foliations generally trending in NW - SE directions. Joints parallel to foliations are common in gneissic rocks.

The major sets of joints are N - S, E - W, NW - SE and NNE - SSW dipping 60° - 80°. The presence of joints, foliations and fracture promotes extensive weathering of the tabular land mass. Due to residual weathering and geochemical leaching of weathered rock laterite, bauxite and kaolinite have been developed. The laterite is cemented by ferruginous and aluminous stiff substance. The bauxite is associated with laterite and there is no dividing line between bauxite and laterite has been found. The thickness of laterite varies from 5 to 20m. The transitional zone between bauxite and kaolinite is called lithomarge and its thickness varies from 4 to 5m. The thickness of kaolinite varies between 8 and 10m. Julka (1990), Guha, (1967).




Geological map of Jharkhand **(Reference JSAC & DMG, RANCHI, JHARKHAND)**




The general geological succession is as given below:

| AGE | FORMATION |
|---|---|
| Recent to Sub - Recent | Soil<br>Laterite and Bauxite<br>Lithomarge<br>Kaolinite |
| ---------- Unconformity ---------- | |
| Archean | Chotanagpur Granite Gneisses |

**GEOLOGY OF STUDY AREA, BAGRU PAT, LOHARDAGA, JHARKHAND**

## 3.1 LOCATION AND ACCESIBILITY:

The area is located about 15 Km NW of Lohardaga district and about 85 Km west of Ranchi. Lohardaga railway station is 16 Km away from the study area.

| Village | Block | District & State | Area in ha. | Ownership & Land Use |
|---|---|---|---|---|
| Bagru Pat | Kisko | Lohardaga, Jharkhand | 214.57 | Private Land. & Govt. forest Land |

The area under investigation occupies an extent about 214.57 ha. around the Bagru Pat village (Latitudinal Extent-23°16′45"N to 23°40′30"N and Longitudinal Extent-84°23′50"N to 84°23′50"E ), of Kisko Block, Lohardaga District.

## 3.2 TOPOGRAPHY

The area is located on Survey of India Topo-sheet No. 73A/10 & 73A/11, having latitude 23°29′21"N and longitude 84°35′48"E. The area about 214.57 ha. falls under the vicinity of village Bagru Pat in the Kisko Block of Lohardaga District, Jharkhand, India.

(Part of toposheet No. 73A/11)

## 3.3 GEOMORPHOLOGY

Lohardaga district is a part of the Chhotanagpur plateau which is situated in the western part of the plateau. The terrain is highly undulating in nature. The plateaus are covered with laterite having the average thickness of 50m. In some places the laterites are enriched with aluminium and contain huge amount of bauxite. The average elevation of the district vary between 610 to 640mas. The Lohardaga district is divisible into following two physiographic unit.

1. Plateau region:- The average height of such plateau is 1000 m above mean sea level. The plateaus are covered with laterite having the average thickness to the tune of 50 m.

2. Peneplain area.:- The average altitude of the peneplain area is around 600 mean sea level. Residual hills of different altitudes dot the peneplain area.

## 3.4 SOILS

The farming situation in the district are mainly dependent on soil, topography and fertility of soil in the area. A varient of alfisols soil is a red sandy soil occurring mainly in plateau and hilly regions. These soils have poor fertility and needs more water for crop production. The different types of soil encountered in the district are alluvial soil, grey eroded scrap soil, red calcareous soil, laterite and forest soils.

## 3.5 CLIMATE

The district experience warm humid climate with three well defined seasons i.e. Summer, Winter and Monsoon. The winters commence from middle November and extend up to middle of March. December is the coldest month. During winter the temperature goes down to 4°c. Summer starts from middle of March and continues up to middle of June, when the temperature shoots up 42°c

## 3.6 RAINFALL

The monsoon sets in by the middle of June and continue till the middle of October. The annual normal rainfall in the district is 1137 mm. 83.5% of total rainfall occurs during the monsoon months only i.e. middle of June to middle of October. The district experiences maximum precipitation in July. The month wise normal rainfall of the Lohardaga district is as follows –

**Normal rainfall data of Lohardaga district**

| Sl. No. | Month | Normal Rainfall in mm |
|---|---|---|
| 1 | January | 17.7 |
| 2 | February | 31.2 |
| 3 | March | 17.3 |
| 4 | April | 23.0 |
| 5 | May | 40.8 |
| 6 | June | 137.3 |
| 7 | July | 305.0 |
| 8 | August | 294.1 |
| 9 | September | 212.8 |
| 10 | October | 44.2 |
| 11 | November | 9.7 |
| 12 | December | 4.3 |

## 3.7 HYDROGEOLOGY

The study area is underlain by hard rock formations belonging to the Pre-Cambrian period and recent alluvium, confined to the valley part. The geology and the structure of the underlying basement control and the occurrence and movement of ground water. No primary porosity is available in the hard rock formation and the ground water occurs in secondary porosity such as joints, fractures and the extent of interconnections within them, facilitates ground water movement.

Ground water occurs within the weathered residuum at favorable locations.

The average thickness of the weathered residuum of the district varies from 15 to 20 meter. Besides, the patches of laterite deposits contain copious amount of ground water within its primary porosity in the western part of the district . The valley has been formed mainly by South Koel and its tributaries like Sankh. Ground water also occurs in the unconsolidated sediments deposited by these rivers.

The weathered profile in the area begins with a fresh host rock at the bottom and progresses upward to: -

(a) Fractured and fissured rocks having low porosity but moderate permeability in fracture system.

(b) Semi-weathered rocks of thickness between 50 - 70m having low porosity and appreciable permeability.

(c) Bauxites and Laterites up to 20m thickness having high porosity and moderate permeability.

(d) Massive clay laterites known as kaolinites and lithomarge up to 30m thickness with porosity but low permeability.

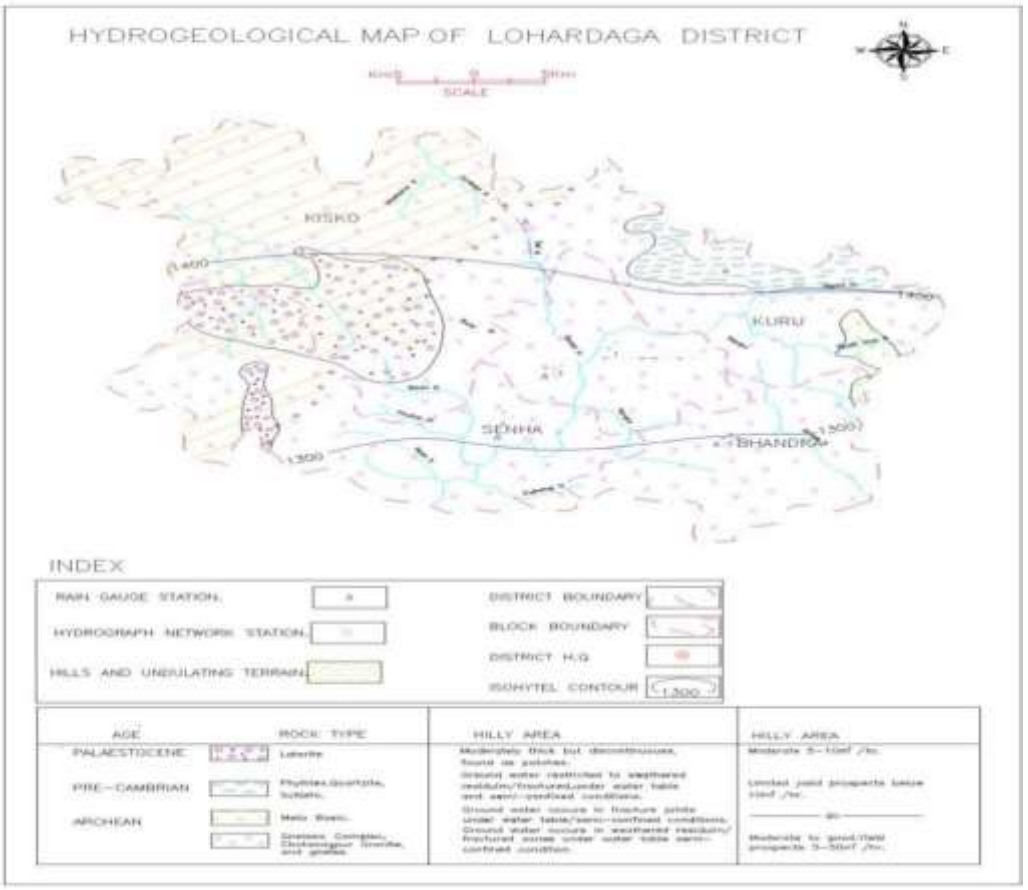
The groundwater stored in weathered rock is intermittently replaced by direct infiltration from rainfall the weathered layer tends to be discontinuous both laterally and vertically and the plateau is bisected by steep scarps. All recharge is of local origin and not supplied by some distant sources the amount of recharge to groundwater in weathered rock depends on total rainfall; intensity and duration of individual rain storm and evapotrpiration which is a function of altitude and temperature.

## 3.8 DRAINAGE AND PHYSIOGRAPHIC PATTERN

The district Lohardaga falls in Chhotanagpur Plateau. The district is bounded by Latehar and Chandwa at the North, Ghagra and Sisai at the South, Bero and Chanho at the East and Bishunpur and Garu blocks at the West. The average height of the district is 636 meter from the m. s. I. whereas the maximum height at Bagru Complex (1057m).

The area is mainly drained by the South Koel River and its tributaries although some portions are also drained by North Koel and Sankh rivers and their tributaries Bhagat and

Adyalkar (1981),Verma (1982). Some perennial nallas are also here which are more pronounced in rainy season, e.g. from highland in the west of Jamun Toli village at Bagru area a perennial nala flows towards NW-WS direction and the water remains throughout the year. The general slope of the district is NE-SW. The existent nallas only helps to drain out rain water during monsoons. However, several nallas originates from the slopes of these hills and flow down into the valley. These small nallas combine as they flows into the valley/plains and forms perennial streams known locally as Phuljhar Nalla, Bakri Nalla, Banki Nalla, Sukri River, Shankh River and Kisko River etc. However, hilltop remains very dry so much so that even during the rainy season, it is difficult to find water on the hill top even a couple of hours after it has stopped raining. Rainwater doesn't infiltrate deep down in area due to the existence of lithomarge and clay below the bauxite. All rain water percolate down to the escarpment slopes and falling to the valleys below. Thus the water table on the hill tops is at quite great depth.




Hydrogeological map of Lohardaga District

## 4. OBJECTIVE OF THE INVESTIGATION AND MOTIVATION:

The proposed research aims to conduct a comprehensive study on the geological and hydrogeological aspects of Bauxite mines and their potential impacts on the surrounding aquifers in Jharkhand. The state of Jharkhand is known for its rich mineral reserves and extensive mining activities, which have raised concerns about the potential impacts on the groundwater resources in the region. This study seeks to address this critical issue by integrating geological, hydrogeological, and environmental assessments.

## 5. PROBLEMS TO BE INVESTIGATED:

- **Geological Mapping:** Conduct detailed geological mapping to identify the distribution, thickness, and geological structures of the bauxite deposit in the area.

- **Hydrogeological Assessment:** Evaluate the hydrogeological properties of the area, including aquifer characteristics such as permeability, porosity, and groundwater flow patterns.

- **Water Quality Analysis:** Assess the baseline water quality of the surrounding aquifer and monitor any changes resulting from bauxite mining activities, including potential contamination from leaching of minerals and chemicals.

- **Groundwater Level Monitoring:** Establish a network of monitoring wells to track changes in groundwater levels over time.

- **Environmental Impact Assessment:** Conduct a comprehensive assessment of the potential environmental impacts of bauxite mining on the surrounding aquifer, including contamination, and changes in water availability for local communities and ecosystems.

- **Stakeholder Engagement:** Engage with local communities and other stakeholders to ensure their concerns are addressed and to facilitate participatory decision-making in the management of water resources and environmental protection.

## 6. RESEARCH DESIGN AND METHODOLOGY:

The proposed approach for the research study is as follows:

a. **RESEARCH OBJECTIVES:**

- To characterize the geological and hydrogeological properties of the bauxite mine area.
- To assess the impact of bauxite mining activities on the surrounding aquifer.
- To identify potential risks to water quality and quantity in the aquifer due to mining operations.

b. **STUDY AREA :**

- Select a specific bauxite mine site and its surrounding aquifer as the study area.
- Consider the geological and hydrogeological characteristics of the area, including the type of bauxite deposit, aquifer properties, and existing water resources.

c. **DATA COLLECTION METHOD** :

- Conduct geological mapping and surveying of the bauxite mine area to understand the geological formations and structures.
- Perform hydrogeological investigations, including groundwater sampling, and monitoring well.
- Collect water quality data from the aquifer and surrounding water bodies to assess potential contamination from mining activities.

d. **DATA ANALYSIS TECHNIQUE** :

- Analyze geological data to understand the mineral composition, stratigraphy, and structural features of the bauxite deposit.
- Use hydrogeological modeling to simulate groundwater flow, recharge, and potential impacts of mining on aquifer dynamics.
- Conduct statistical analysis of water quality data to identify any changes or contamination related to mining activities.

e. **IMPACT ASSESMENT:**

- Evaluate the potential impact of bauxite mining on the aquifer's water quality and flow patterns.
- Assess the risk of groundwater contamination from mining-related pollutants and assess the potential for mitigation measures.

f. **RESEARCH METHODOLOGY :**

- Employ a combination of field investigations, laboratory analysis, and modeling techniques to gather and analyze data.
- Use a multi-disciplinary approach involving geologists, hydrogeologists, environmental scientists, and mining engineers to ensure comprehensive data collection and analysis.

g. **INTERPRETATION AND CORRELATION:** The interpretation and correlation will be made on the basis of results obtained by above analysis.

## 7 TOOLS TO BE USED IN THE COLLECTION OF DATA:

- GPS
- Field books
- Ph meters
- Topographic maps
- Geological map
- 1 litre capacity Polyethylene bottles

(Other tools can also be used during research work depending on the availability)

## 8. SIGNIFICANCE OF THE WORK, ITS RELEVANCE TO THE PRESENT DAY PROBLEM AND NEED OF THE SOCIETY:

The significance of conducting water analysis on bauxite mine waters is that it provides insights on the contribution of bauxite mining to the pollution of the nearby water sources. Bauxite mining, which involves extracting aluminum ore from the earth, is a process which can result in the pollution of the nearby water bodies with an array of chemicals and heavy metals. This makes it all more necessary to do a comparative study of water quality in and around bauxite mines for this industry pollutant release investigation.

The present day issue justifies why such investigations are current since there is major quest for aluminium resulting into more bauxite exploitation. With increasing world's need for alumina, there will be creation of new sites for bauxite minerals thus prospective environmentality. There justice has to be served by

considering the fact that degradation of aquatic habitats through bauxite mining poses serious harmful consequences both to human health as well as the overall economic activities and liveihoods o f communties living within affacted areas.

The justification of conducting this study is clear considering the importance of sustainable development and environmental conservation. There is an increasing concern about the preservation of natural resources and the reduction of the impact of industrial activities on the environment, thus, there is a great need to decipher and eventually lessen the curse that bauxite mining imposes on water quality. Through a careful analysis of water in bauxite mining areas researchers are capable to give a lot of useful information for decision-makers, industry stakeholders, as well as for local communities so that they can develop approaches directed at environment protection and sustainable resources management system.

## 9. CONTRIBUTION TO THE EXISTING KNOWLEDGE, FUTURE WORK:

Research related to analysis of bauxite mine water seeks to improve the already existing knowledge by offering a complete comprehension in regards to its chemical make up and what possible environmental concerns are associated with it. The research is conducted through collection and analysis of water samples at bauxite mining sites to find out how much various pollutants contaminate such waters as heavy metals, acidity, and others. Research also searches for the potential sources of these contaminants and their impact on surroundings including soil quality and water quality.

The findings of the study serve as an addition to the current knowledge presented in literature by giving important views about issues connected with bauxite mining activities. This data can be employed for devising effective interventions which help in risk mitigation as well as decreasing the negative impacts on earth. Furthermore, it is not far-fetched that this research will aid in forming principles or regulations that manage mine water precisely for environment and people's safety purpose.

Research on bauxite mine water analysis could be deepened by giving a detailed analysis of the long-term environmental issues that mining activities cause. This will maybe include watching over the changes in water quality over a period of time and evaluating how effective mitigation measures are. Moreover, later research can also concentrate on innovating technologies for treating mine waters to cut down the contaminant levels, and hence, save the environment from harm. Further work in this area next can be another step forward with regard to increasing our current knowledge with regards to environmental impact of bauxite mining as well as devising efficient strategies to offset them.

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